United States Patent [19]

Biersach

[11] **Patent Number: 5,006,391**

[45] **Date of Patent: Apr. 9, 1991**

[54] **HONEYCOMB STRUCTURE AND METHOD OF MAKING SAME**

[76] Inventor: **James R. Biersach**, 511 Kimberlee Drive N., Baxter, Minn. 56401

[21] Appl. No.: **424,947**

[22] Filed: **Oct. 23, 1989**

[51] **Int. Cl.**[5] **B32B 3/12**

[52] **U.S. Cl.** **428/116**; 156/153; 156/292

[58] **Field of Search** 156/197, 292, 153; 428/73, 116, 117, 118

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,477,852	8/1949	Bacon	428/116
2,839,442	6/1958	Whitaker	428/116 X
3,007,834	11/1961	Moeller et al.	428/116 X
3,483,070	12/1969	Kennedy et al.	428/118

Primary Examiner—Henry F. Epstein

Attorney, Agent, or Firm—Henry C. Kovar

[57] **ABSTRACT**

A new and improved honeycomb core and honeycomb panel are provided with a new method of making honeycomb cores and panels. The honeycomb core is fabricated from conventional or higher quality corrugated fiberglass sheet and the honeycomb panel has a resin core that is fiber filled for strength. The method of making the core sheet has the steps of providing corrugated rigid resin panels, abraiding the corrugation apexes on both sides of the corrugated panels, applying adhesive on the abraided apexes, stacking the corrugated panels with every other corrugated panel being flipped over so that the apexes face each other, bonding the apexes and therefore the corrugated panels together to form a core block, and then sawing desired thicknesses of core sheets off of the core blocks. The core sheets are subsequently bonded into finished honeycomb panels.

12 Claims, **3 Drawing Sheets**

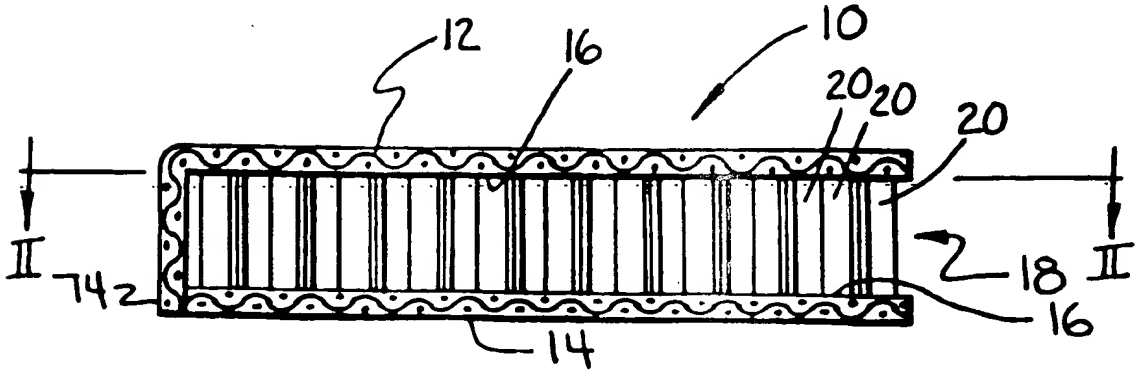


FIG.1

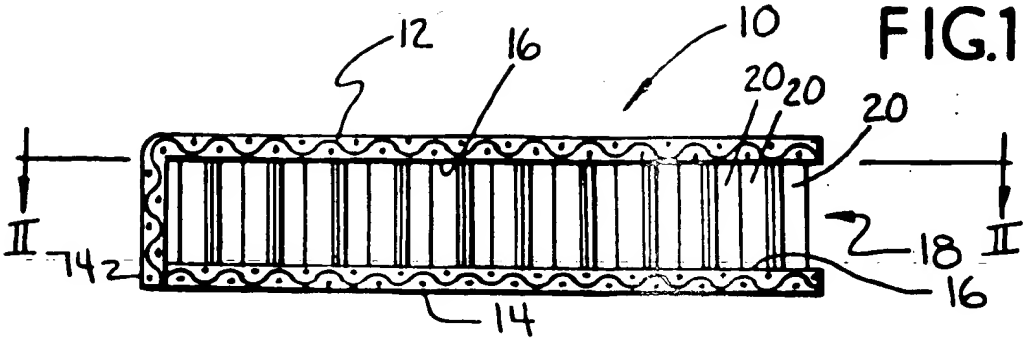


FIG.2

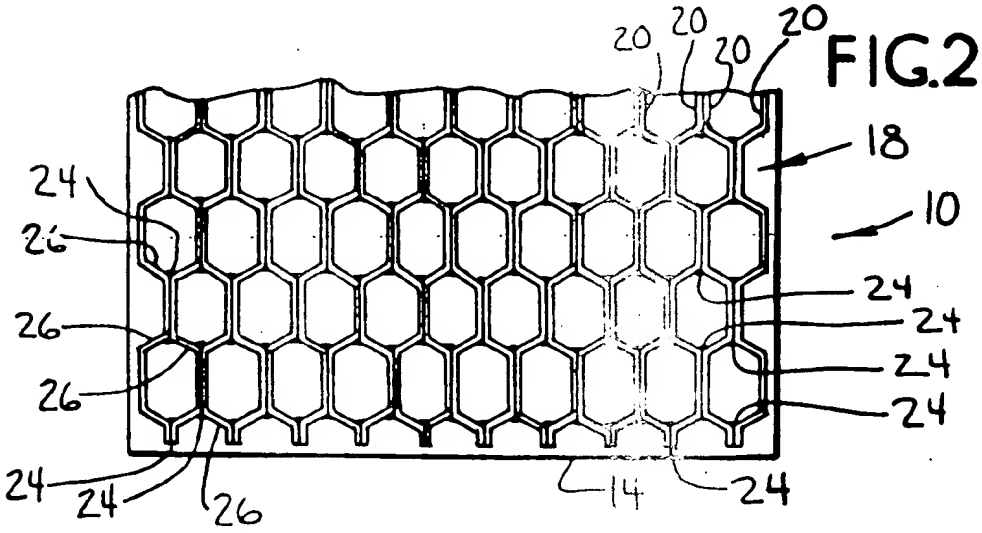


FIG.3

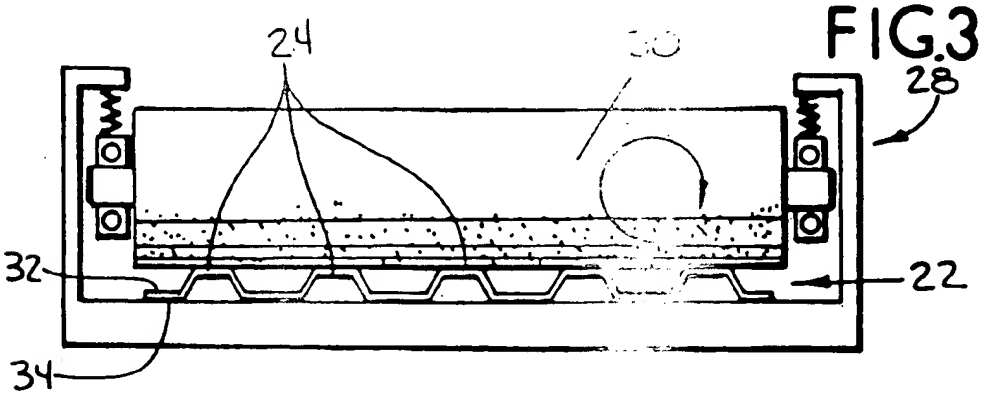


FIG.4

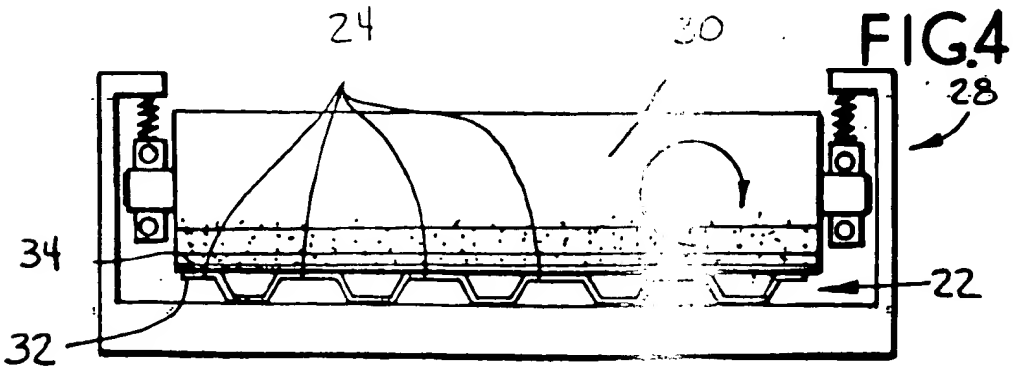
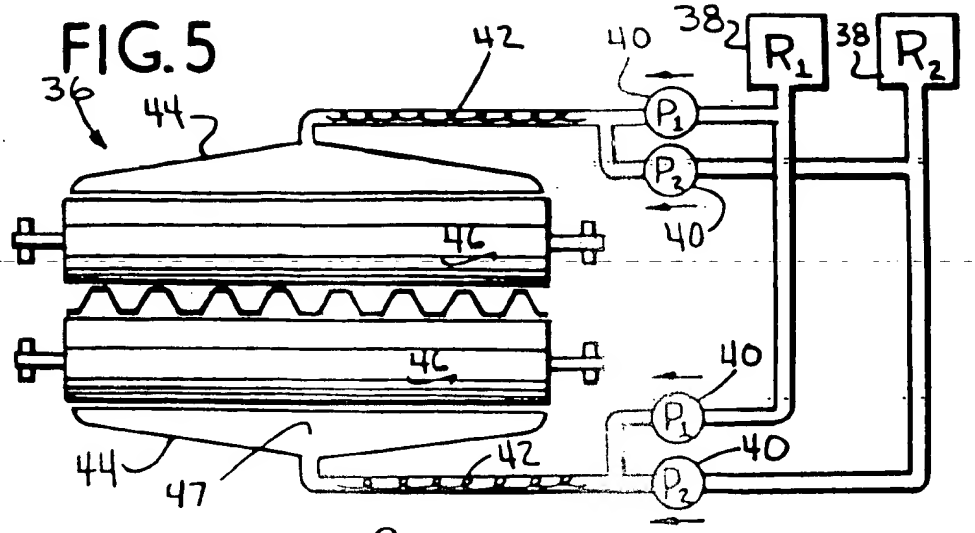


FIG.5



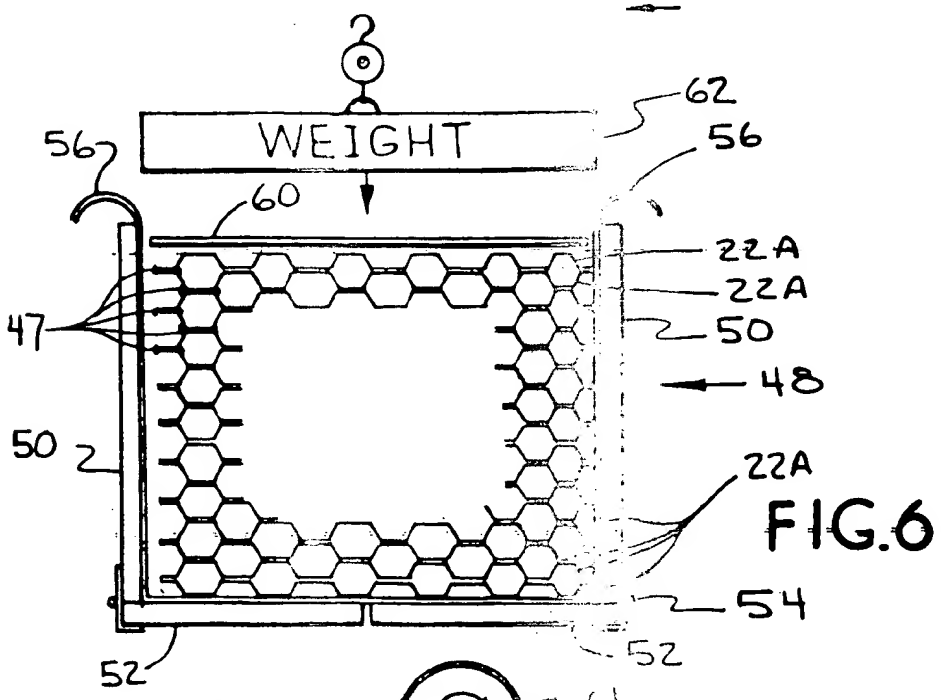


FIG.6

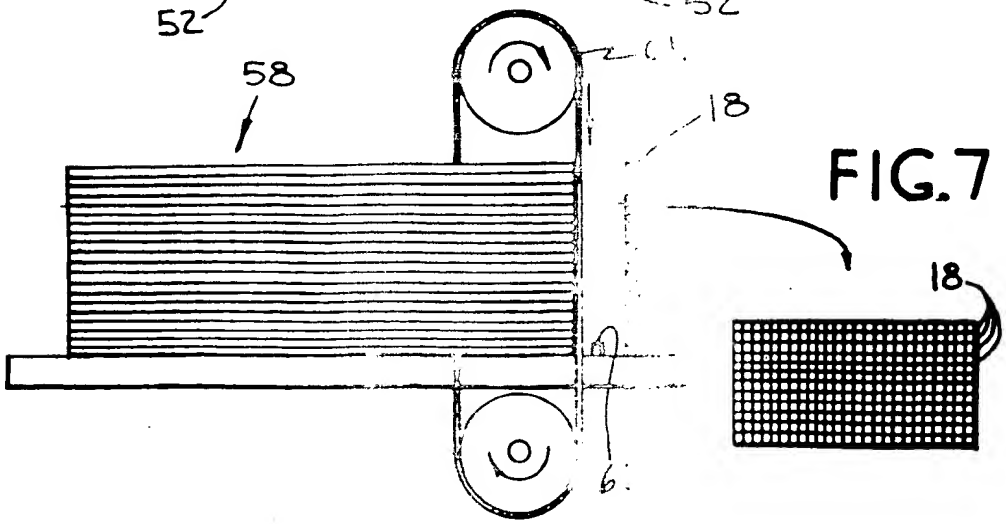


FIG.7

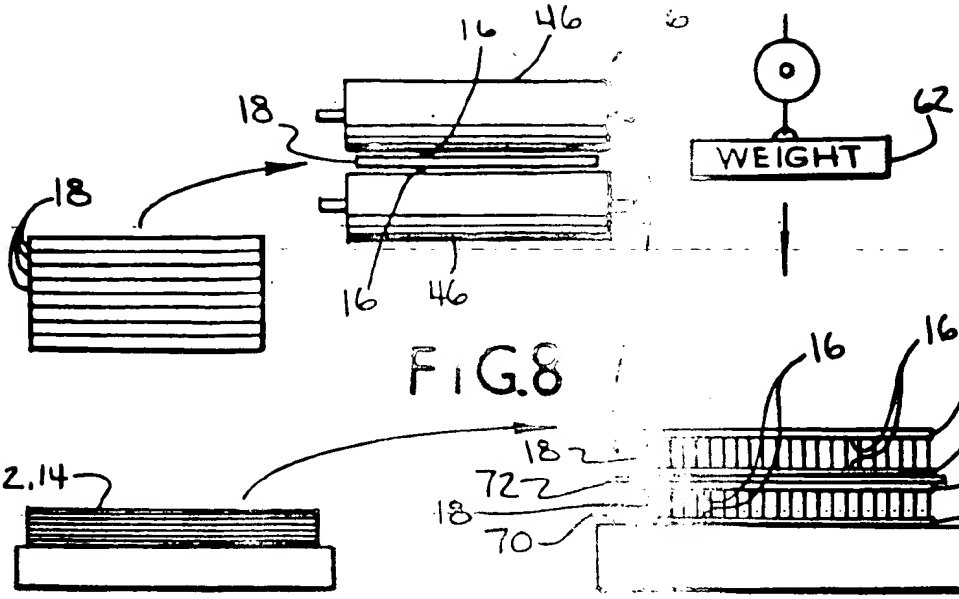

16
46
18
18
WEIGHT
42
16
46
12,14
18
72
18
70
16
16
14
12
14
12

FIG.8

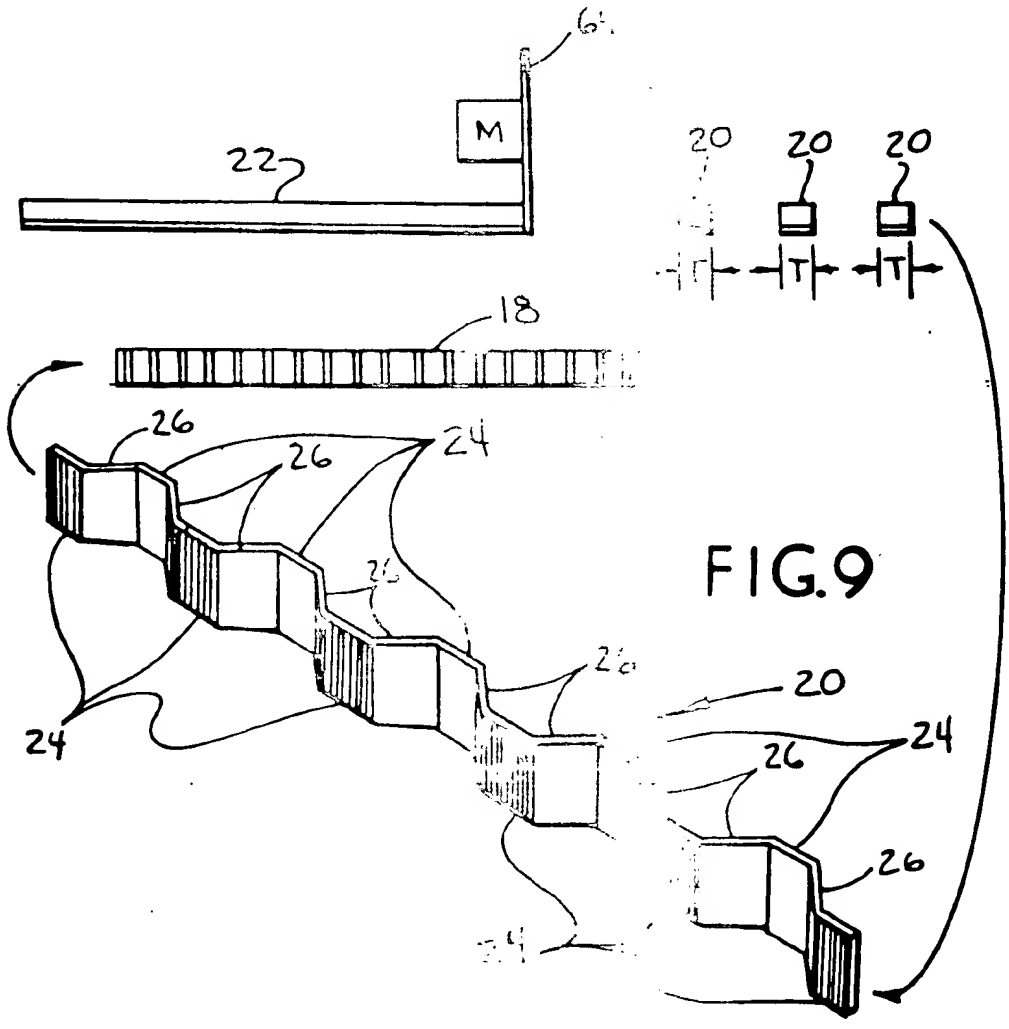

64
M
22
20
20
20
T
T
T
18
26
26
24
24
20
24
26
26

FIG.9

HONEYCOMB STRUCTURE AND METHOD OF MAKING SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to a new honeycomb structure and to a new method of making structural honeycomb.

2. The Prior Art

Honeycomb is generally described as a structure of hexagonal thin walled cells. Most honeycomb structural panels have a central core of thin walled cells, and a structural skin secured on the outer surface of each side of the core, with the skins being normal to an axis of the cells. The cells can be either exactly or approximately hexagonal, or square or of some other geometric shape.

The most commonly encountered honeycomb structures in nature are bee, wasp and hornet made structures.

Man made honeycomb structures are being used for many purposes. The typical use will require light weight, stiffness and high strength. Typical actual specific honeycomb uses are floors in aircraft and load carrying vehicles, platforms, walls and building panels, doors, sporting equipment, pallets and skids, and packaging. These specific uses will typically have a structural skin on both sides of the core.

Honeycomb core with a skin on only one side also has utility and is used for material handling and distribution, ammunition storage, fuel cell cores, molding and for other purposes.

A wide variety of materials have been and are used as outer structural skin material, ranging from simple cardboard to the most esoteric fiber filled resins of the aerospace and armor industries.

Material usage in the honeycomb core has, however, been restricted to lesser performance materials such as paper, cardboard, and aluminum. All these core materials have corrosion suceptibility problems and none are effectively useable in water and many other corrosive liquids and environments.

The paper and cardboard cores degrade when wet, and both the paper and aluminum cores are attacked by bases or acids.

Usage of these honeycomb structures has been limited to dry and somewhat protected environments.

The core materials being used have not been of particularly high strength. The aluminum honeycomb must use an alloy that can be formed to make the cellular structure and the extremely high strength relatively brittle alloys used for flat panel aerospace applications cannot be effectively used.

There is only one known example of fiber reinforced resin honeycomb core in use, and it is available under the Hexcel brand name. This particular material uses long fiber made into something resembling paper which is provided in a soft non-rigid form. Specifically it's in a folding accordian type structure that can be compressed and stretched and matched to single panel or compound contours. It is available in a maximum thickness of about 6 mm (0.24 inch) and costs about $3 per square foot. This material is then bonded and made rigid by being dipped one or more times in a penetrating resin. The more times you dip this core, the more resin you build up. The specific end uses of this core material are not fully known but its cost must restrict its effective use to aerospace and/or military end uses.

OBJECTS OF THE INVENTION

It is an object of this invention to provide a new honeycomb structure having an improved fiber and resin core.

It is an object of this invention to provide an improved honeycomb core of corrugated fiberglass.

It is an object of this invention to provide a new honeycomb panel having at least one surface sheet and an improved attached fiberglass cellular structure.

It is an object of this invention to provide a new method of making honeycomb core.

It is an object of this invention to provide a new method of making honeycomb panel with an improved fiberglass cellular structure.

SUMMARY OF THE INVENTION

A new honeycomb core has a plurality of corrugated ribbons of resin panel, the apexes of the ribbons are abraded and permanently bonded together.

A new honeycomb panel has at least one surface sheet and honeycomb structure secured to one side of the surface, the honeycomb structure is formed by a plurality of corrugated cell walls which are sublengths of a corrugated rigid resin panel.

A honeycomb panel has first and second surface sheets, a honeycomb core devised of corrugated rigid resin panels, an adhesive permanently securing the sheets to one side of the core.

A method of making honeycomb core has the steps of preparing the apexes on both sides of a rigid corrugated plastic panel, applying adhesive bonding, applying adhesive to the prepared apexes, placing the panels in a stack, curing to form a core block, and cutting core sheets off the core block.

A method of making honeycomb core has the steps of providing a plurality of pieces of rigid corrugated fiber reinforced resin, arranging the pieces in position against each other with corrugation apexes of adjacent pieces against each other, and permanently bonding the abutted apexes to each other to form the core.

Other advantages, features and additional objects of the invention will become manifest to those versed in the art upon making reference to the detailed description and accompanying drawings in which a preferred embodiment incorporating the principles of the present invention is set forth and shown by illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the preferred embodiment of the honeycomb panel of the present invention;

FIG. 2 is a view in section through lines II of FIG. 1;

FIG. 3 is a perspective view of the processing of the honeycomb core;

FIG. 4 is a perspective view of the processing of the honeycomb core;

FIG. 5 is a perspective view of the adhesive application to the honeycomb core structure from FIGS. 2 & 3;

FIG. 6 is a perspective view of the bonding of the honeycomb core of FIG. 5;

FIG. 7 is a perspective view showing the cutting of the honeycomb core sheets;

FIG. 8 is a process flow diagram of the assembly of the completed core panels; and

FIG. 9 is an alternative process flow diagram.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the principles of the present invention, the preferred embodiment of the new and improved honeycomb panel of the present invention is shown in FIGS. 1 and 2 and generally designated by the numeral 10, and hereinafter referred to as the panel 10 for brevity.

The panel 10 has at least one and usually two outer surface sheets 12, 14 which are spaced apart from each other and which are of a conventional material such as wood, fiber resin, metal, ceramic and so on. The inner surface of each surface sheet 12, 14 has a layer of appropriate adhesive 16 which is preferrably an irreversible two-part reactive structural adhesive such as an epoxy resin. Within the surface sheets 12, 14 and the adhesive 16 is a new honeycomb core sheet 18 which is an important part of this invention. The core sheet 18 is permanently bonded to the surface sheets 12, 14 with and by the adhesive layers 16.

The core sheet 18 is comprised of a plurality of ribbons 20 of rigid corrugated resin panel pieces, which preferrably are fiber filled for structural re-inforcement. These ribbons 20 are cut either singularly or in bonded pluralities from one or more rigid corrugated resin panels 22 as will be explained.

Each panel 22 as shown in FIGS. 3 and 4 is a panel of nominal width and length, for example 4 feet wide and 12 feet long. The panel 22 has a plurality of corrugations that run the length of the panel 22 and which are evenly uniformly spaced from each other across the transverse width. On each side of each panel 22 and therefore each ribbon 20 is a plurality of corrugation apexes 24 which define the outermost surfaces on each side of the panel. The apexes 24 are preferrably flats, and each apex has a transverse flat dimension which is at least ⅓ the transverse width of a complete corrugation wave. The thickness between opposing apexes 24 are thickness legs 26. The panels 22 of conventional build are commonly found in lumber yards and are used for the conventional construction of buildings, roofs, walls, shelters, and so forth. Be it understood that high cost and high performance aerospace resins and fibers are also usable as material for the panels 22 and ribbons 20 and that various extrusion and/or formed profiles of the panels 22 and ribbons 20 are usable in this invention. However, the invention is particularly cost effective with fiberglass reinforced polyester resin panels.

In the method of making the ribbons 20 and the core sheet 18, the entire panel 22 is firstly prepared for bonding a honeycomb material by being run through a sander 28 which has an abrasive wheel or belt 30 that abrades the entire surface of each and every corrugation apex 24 on a first side 32 of the panel 22. The panel 22 is then flipped over and again run through the sander 28 which abraids entirely, each and every surface of every corrugation apex 24 on the second side 34 of the panel 22. On high production facilities, it is recognized that a double wheel sanding machine can abraid both panel sides 32, 34 at one time and during a single pass.

The abraided panel 22A is then run through an adhesive application machine 36 as shown in FIG. 5 which has vats 38 for adhesive parts 1 and 2, adhesive pumps 40, adhesive mixers 42, adhesive spreaders 44 and ap-

cation rollers [illegible] Alternatively the core adhesive 47 can be applied by [illegible] with rollers or brushes. Regardless, core adhesive [illegible] applied to all the prepared apex surfaces 24 of [illegible] one panel side 32 and also preferrably on the [illegible] surfaces 24 of the second panel side 34. The prepared panels 22A with the core adhesive 47 thereon are then transferred to the honeycomb core jig 48.

The core jig shown in FIG. 6 is a box having sides 50, ends (not shown) and single or double bottom doors 52. The doors 52 lock in the closed position and an expendible box liner 56 is used for each block-fabrication. The preferred liner 56 is plastic film. The jig 48 is sized to be a reasonably close fit to the panels 22 so that the panels 22 align and stack upon another. A plurality of prepared panels 22A are placed into the jig 48 as the adhesive panel 22A is flipped or inverted. For example the first and bottom panel 22A will have its first side 32 down and a second panel 22A will have its first side 34 down. All of the odd numbered panels 1, 3, 5, 7, 9, 11, and so forth (bottom) will be like the bottom panel and the even numbered panels 22A (panel 2, 4, 6, 8, 10, 12 and so forth) are all positioned panel 22A. The total number of panels 22A in the jig 48 determines the height of the core sheet 18 and the desired quantity of prepared panels 22A have been placed in the jig 48, a [illegible] is placed upon the top panel 22A and a [illegible] is placed atop the stack of panels 22A. The adhesive 47 is then cured whereupon the adhesive [illegible] sets and the individual panels 22A are [illegible] structurally adhesively bonded [illegible] and finish the bonded core block 58 is then opened and the core block 58 [illegible] the liner 56 up and out of the core block 58 in the line 56.

The core [illegible] taken to a bandsaw 64, as shown in [illegible] adjustable stop 66 is set to produce [illegible] of core sheet 18 and, the individual [illegible] sheets 18 are cut off of the core block in a stack as shown. The [illegible] are sawed with parallel sides [illegible] however, variable thicknesses [illegible] easily done.

As shown [illegible] stack of core sheets 18 and a [illegible] surface sheets 12 14 are then [illegible] line 36. The core sheet 18 [illegible] 12, 14, is preferrably run [illegible] minimize the consumption of [illegible] the weight of the finished [illegible] 12 is placed on a support [illegible] ted core sheet 18 is placed [illegible], a second surface sheet 14 [illegible] sheet 18, a release sheet 72 [illegible] panel 10, and a second set [illegible] core sheet 18 are stacked up, [illegible] a stack of assembled and [illegible] weight 62 (or a different [illegible] pressure or vacuum bags) is [illegible] assembled panels 10 and [illegible] 10 and the adhesive 16 is [illegible] honeycomb panels 10 are [illegible] and completed.

Referring back to FIGS. 1 and 2, it can now be appreciated that the core sheet 18 within the honeycomb panel 10 has a plurality of corrugated rigid resin ribbons 20 which preferrably are fiber reinforced, that are arranged with these prepared and abraided apexes 24 abutted against each other and permanently bonded to each other with adhesive 47, which may be identical to the surface sheet adhesive 16 composition. All of the ribbons 20 are of identical height when it is intended to have the surface sheets 12, 14 parallel to each other. The complete honeycomb panel 10 is then ready for subsequent processing into a finished product. Examples of finished products include shelving, flooring, bulkheads, diving boards, docks, wall panels, partitions, ramps, pallets, swimming platforms, pontoon boat decks and the like. The preferred core sheet 18 has ribbons 2[illegible] taken from a panel 22 which has corrugation apexes [illegible] with flats that enhance preparation and bonding. The preferred cellular profile is generally hexagonal as seen in FIG. 2, but may also be generally square or of other configurations.

FIG. 9 illustrates a process wherein a prepared and abraided single corrugated panel 22 is sliced by the saw 64 to make individual core ribbons 20 that are subsequently bonded into a single layer core sheet 18 which may be flat or have single or multiple curvature of its surfaces.

Returning to FIG. 1, an integral flange 74 is shown on the surface sheet 12. The flange 74 is extendible around the entire periphery of the first surface sheet 12 providing hermetic sealing to the second surface sheet 14 during assembly and bonding of the finished honeycomb panel 10.

The new and improved honeycomb core sheet 18 and the new and improved completed honeycomb core panel 10 are usable in environments where conventional and known honeycombs will be environmentally attacked and fail. Specific examples are in building construction, sporting goods, vehicles, uses submerged and floating on water, uses in agressive chemical environments, an uses in factories.

The new methods of fabricating the core sheet 18 and the finished core panels 10 can be effectively practiced by a single person, a small business, or a large businesses. The materials to practice the method and build the finished products are available at [illegible] yards. The finished core panel 10 is relatively low cost and is of high economic value.

Although other advantages may be found and realized and various modifications may be suggested by those versed in the art, be it understood that I embody within the scope of the patent warranted hereon, all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. An improved honeycomb core comprising

(a) a plurality of corrugated ribbons of preformed rigid corrugated resin panels, said ribbons having mechanically abraided exterior apexes; and

(b) adhesive permanently bonding facing flats of said abraided apexes together.

2. The core of claim 1, in which each said apex has an abraided flat area with a transverse width which is at least ¼ of the corrugation wavefor[illegible]

3. The core of claim 1, in which said resin is fiber reinforced.

4. [illegible] fiber[illegible] entire[illegible]

5. [illegible] flippe[illegible] adjac[illegible]

6. [illegible] (a) [illegible] (b) [illegible]

7. [illegible] entir[illegible] cor[illegible]

9. [illegible] me[illegible]

[illegible] ai[illegible] abraid[illegible] rib[illegible]

[illegible] co[illegible]

[illegible] s[illegible]

[illegible] co[illegible]

[illegible] of claim 3, in which said ribbons are of [illegible]rced polyester panels and in which the [illegible] each bonded apex is abraided.

[illegible] claim 1, in which every other ribbon is [illegible]be the mirror image of the immediately [illegible]joined ribbons.

[illegible]mb panel comprising [illegible]e surface sheet, [illegible]mb core structure permanently secured [illegible]of said surface sheet, said honeycomb [illegible] being a plurality of corrugated cell [illegible] and secured first side to second side [illegible] second side and so on, said cell walls [illegible]gth ribbons of a preformed corru[illegible]sin panel; [illegible] braided corrugation apexes on both [illegible] ribbons; and [illegible]ing opposing and abutted together [illegible] to each other.

[illegible]mb panel of claim 6, in which the [illegible]face of every corrugation apex is [illegible].

[illegible]anel, comprising [illegible]d surface sheets, [illegible]re in between and spacing said [illegible], said core being a plurality of [illegible]ns from a rigid corrugated resin [illegible]

[illegible] abraided exterior corrugation [illegible] sides of adjacent ribbons; [illegible]manently securing said abraided [illegible]ther; and [illegible]ntly securing said surface sheets [illegible]f said core.

[illegible]im 8, in which said panel is sub[illegible]id sheets and said core being non[illegible]erbant in water.

[illegible] claim 8, in which said ribbons have [illegible]exes adjoined to each other, said [illegible]ing at least ¼ of the width of each [illegible] each flat apex being abraided.

[illegible]king an improved honeycomb [illegible]ps of [illegible]aiding outer corrugation apexes [illegible] each panel in a plurality of rigid [illegible] panels, in preparation for adhe[illegible]

[illegible] of adhesive on the abraided [illegible]

[illegible]s in a stack, with said adhesive [illegible]xes being in opposing face-to[illegible]ach other; [illegible] of panels together while curing [illegible]onding the abraided apexes to[illegible] forming a core block; and [illegible] core sheets off of an end of the [illegible]

[illegible]king an improved honeycomb [illegible]ps of [illegible]ty of pieces of preformed rigid [illegible]nforced plastic panels; [illegible]iding outer corrugation apexes [illegible]paration for adhesive bonding [illegible]g adhesive thereon; [illegible]es in position against each other [illegible]corrugation apexes of adjacent [illegible] against each other; and [illegible]ding the abutting abraided [illegible]r and forming the improved [illegible]om said rigid plastic panels.